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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q , H04L

A2

(11) International Publication Number: **WO 98/43446**

(43) International Publication Date: 1 October 1998 (01.10.98)

(21) International Application Number: PCT/SE98/00536

(22) International Filing Date: 24 March 1998 (24.03.98)

(30) Priority Data:
08/827,029 25 March 1997 (25.03.97) US

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 15 Stockholm (SE).

(72) Inventors: ANDERSSON, Dick; Kastrupgatan 3, S-164 41 Kista (SE). AXELSSON, Ulf; Travarvägen 63, S-177 59 Järfälla (SE). BÄCKSTRÖM, Martin; Poppelvägen 14, S-141 41 Huddinge (SE). FRID, Lars; Hälsingegatan 3, S-113 23 Stockholm (SE). OLSSON, Ulf; Grindgårdsvägen 15, S-192 77 Sollentuna (SE). PEHRSSON, Arne; Hasselstigen 10, S-141 71 Huddinge (SE).

(74) Agent: ERICSSON RADIO SYSTEMS AB; Common Patent Dept., S-164 80 Stockholm (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: COMMUNICATING PACKET DATA WITH A MOBILE STATION ROAMING WITHIN AN INCOMPATIBLE MOBILE NETWORK

(57) Abstract

A roaming mechanism enabling a mobile station (20) to roam between a first data packet network (300) utilizing a Mobile IP Method (MIM) and a second data packet network (10) utilizing a Personal Digital Cellular Mobility Method (PMM) is disclosed. A foreign agent (FA) (310) is introduced into the PMM network (10) for enabling a mobile station (20) associated with the MIM network (300) and currently roaming within the PMM network (10) to communicate packet data with an associated home agent (HA) (320). A home agent (HA) is further introduced into the PMM network (10) for enabling a mobile station (20) associated with the PMM network (10) and currently roaming within the MIM network (300) to communicate packet data with an associated FA or Mobile IP Client Emulator (MICE) (1000 currently serving the roaming mobile station (20).

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COMMUNICATING PACKET DATA WITH A MOBILE STATION ROAMING WITHIN AN INCOMPATIBLE MOBILE NETWORK

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to packet data communication and, in particular, to the communication of packet data, such as an Internet Protocol (IP) packet, toward a mobile station roaming within an incompatible mobile network.

Description of Related Art

Developments and improvements in mobile telecommunications networks have enable mobile subscribers to communicate data, other than mere voice data, over a serving mobile telecommunications network. With a wide proliferation of Internet and e-mail applications, mobile subscribers are able to access their e-mail messages or even browse or "surf" the Internet via their associated mobile stations. Accordingly, a mobile station may function as data terminal equipment (DTE) in providing Internet access or packet communication to an associated mobile subscriber.

Unlike voice communication, packet communication towards mobile stations has not yet been fully standardized. As a result, a number of different standards, protocols, and/or schemes are available to provide packet communication with a mobile station. Such differences in standards are especially true with respect to maintaining a particular mobile station's current location and its registration status. A method and/or scheme for maintaining data associated with a particular mobile station and its location is referred to as "mobility management" and is needed for enabling a mobile station to freely travel or roam within a particular network.

As an illustration, one such standard requires a separate mobility management infrastructure and routing scheme for effectuating packet communication with a mobile station. Such a standard only utilizes a serving mobile switching center (MSC) and base station (BS) associated with an existing mobile

center (GPMSC), for example, then reroutes packets to a Visited Packet Mobile Switching Center (VPMSC) associated with the identified MSC. The serving MSC and BS associated with the VPMSC then establish a radio link with the destination mobile station to effectuate data packet communication in a conventional manner. Such a standard is commonly referred to as a traditional cellular mobility method. One example of a packet data communications network utilizing such a standard is a Personal Digital Cellular Mobility Method network (PDCMM or more commonly known as PMM network).

Even though there are different types of data packet communications standards, as long as a mobile station roams within a mobile telecommunications network utilizing a compatible packet communications standard, a corresponding mobility management scheme communicates with appropriate devices and nodes to enable the mobile station to access packet communication. However, when a mobile station belonging to a first mobile telecommunications network utilizing a first packet communications standard roams into a second mobile telecommunications network utilizing a second packet communications standard, there is currently no mechanism for enabling the mobile station to access packet data communication while visiting the incompatible second packet telecommunications network. As a result, for packet communication, a mobile station is currently restricted to roam within a compatible mobile telecommunications network.

Accordingly, there is a need for a mechanism to enable a mobile station to roam from a first mobile telecommunications network utilizing a first packet communications standard to a second mobile telecommunications network utilizing a second packet communications standard.

SUMMARY OF THE INVENTION

A system is disclosed for enabling a mobile station associated with a first packet data network to roam within a second packet data network where the data routing mechanisms utilized by the first and second packet data networks are incompatible. To handle the situation where a mobile station associated with a first packet data network utilizing a first mobility management roams into a second

FIGURE 2 is a signal sequence diagram illustrating the handover of a mobile station within a network utilizing the Personal digital cellular Mobility Method (PMM);

FIGURE 3 is a block diagram of a packet data network utilizing a Mobile IP Method (MIM) and illustrating the communication of packet data with a mobile station;

FIGURE 4 is a signal sequence diagram illustrating the handover of a mobile station within a network utilizing the Mobile IP Method (MIM);

FIGURE 5 is a block diagram of two different packet data networks illustrating the roaming of a mobile station from a first packet data network to a second packet data network in accordance with the teachings of the present invention;

FIGURE 6 is a signal sequence chart illustrating the roaming of a mobile station from the first packet data network to the second packet data network;

FIGURE 7 is a block diagram of the second packet data network illustrating the handover of the mobile station associated with the first packet data network from a first visited mobile switching center (VMSC) to a second VMSC;

FIGURE 8 is a block diagram of two different packet data networks illustrating the roaming of a mobile station from the second packet data network to the first packet data network in accordance with the teachings of the present invention;

FIGURE 9 is a signal sequence chart illustrating the roaming of the mobile station from the second packet data network to the first packet data network; and

FIGURE 10 is a block diagram of the first packet data network illustrating the handover of a mobile station associated with the second packet data network from a first visited mobile switching center (VMSC) to a second VMSC.

DETAILED DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a packet data network 10 utilizing a Personal Digital Cellular Mobility Method (PDCMM, hereinafter referred to as a

centralized database associated with the home network for storing subscription data representing the mobile station 20 and for maintaining location data reflecting the mobile station's current location and registration status. Furthermore, the HLR 50 associated with the PMM network further stores data correlating the received mobile identification number with a corresponding Internet Protocol (IP) address assigned to the mobile station 20.

As a result, a location update signal is transmitted from the serving VMSC 40 to the associated HLR 50 (signal link 60) through the backbone network 15. The HLR 50 authenticates the mobile station 20 and provides requisite subscriber data back to the VMSC 40. The serving VMSC 40 may also be associated with a local database, such as a Gateway Location Register (GLR, not shown in FIG. 1), for storing data associated with all mobile stations currently traveling within its coverage area and for communicating with associated HLRs.

Packet data addressed to the IP address associated with the mobile station 20 is transmitted from an origination point. Such an origination point may be within the same serving PMM network 10 or from an external network. For exemplary purposes, packet data originated towards the mobile station from an external node are illustrated herein. Within the PMM network 10, each associated mobile station 20 is assigned with a PMM network dependent IP address. When packet data addressed to an associated PMM allocated IP address is routed, it is first delivered to a gateway packet mobile switching center (GPMSC) 70 serving the PMM network 10. The GPMSC 70 therefore serves as a gateway for receiving all incoming packet data with IP address associated therewith.

The GPMSC 70 then performs an interrogation with the HLR 50 to determine how to route the received packet data. As described above, the HLR 50 retains information regarding the current location of the mobile station. The GPMSC 70 provides the HLR 50 with the received IP address. Utilizing the received IP address and correlated mobile identification number, the HLR 50 is able to ascertain the current location of the traveling mobile station 20. The HLR 50 then returns routing instructions to the requesting GPMSC 70. Such routing instructions include, for example, an Internet Protocol (IP) address representing a

instructions. The HLR 50 returns an identifying address 120 representing the VPMSC1 80 currently serving the mobile station 20. Alternatively, the serving HLR 50 may also return a roaming number representing the serving VMSC1 40. The GPMSC 70, in turn, may identify the VPMSC1 80 associated with the determined VMSC1 40.

Utilizing the received identifying address, an IP tunnel 130 is then established between the VPMSC1 80 and the GPMSC 70. The VPMSC1 80 then delivers the packet data 140 to the VMSC1 currently serving the mobile station 20. The received packet data are then forwarded 150 to the BS1 30 currently serving that geographic area, such as a cell or location area. By way of radio interface 160, the received packet data are then communicated with the traveling mobile station 20.

When the mobile station 20 travels out of the current geographic area being served by the VMSC1 40 and travels into a new geographic area being served by a new VMSC2 45, the mobile station 20 performs a new location update. A packet communication registration signal 170 is then transmitted to a new BS2 serving the new geographic area. The BS2 then forwards the registration request signal 180 to the connected VMSC2 45. The VMSC 45 then similarly forwards the packet communication registration signal 185 to the associated VPMSC2 85. The VPMSC2 85 then performs a location update 190 with the HLR 50 to inform the HLR 50 of the mobile station's new location. The HLR 50, in turn, informs the GPMSC 70 with a new identifying address 200 representing the new VPMSC 85 associated with the new serving VMSC2. The GPMSC 70 then utilizes the new address to establish a new IP tunnel 210 between the GPMSC 70 and the newly identified VPMSC2 85. Subsequently received data are then rerouted to the new VPMSC2 85 via the new IP tunnel 210. The VPMSC2 85 then delivers the received data 220 to the traveling mobile station 20 in a similar manner as described above. As a result, a hand over of the mobile station from the first VMSC1 40 to the second VMSC 45 is effectuated.

Reference is now made to FIG. 3 illustrating a different type of packet data network 300 utilizing a Mobile IP Method (MIM, hereinafter referred to as an MIM network) to communicate packet data with a mobile station. Within the MIM

(FA/SR) 310. The FA/SR 310 then analyzes the IP address transmitted by the traveling mobile station 20 and determines a home agent 320 associated therewith. The HA 320 is a packet data communication node for keeping track of the mobile station's current location and for performing gateway function for receiving and routing incoming packet data. The FA 310 then communicates with the identified HA 320 to establish an IP tunnel 330 therebetween.

Incoming packet data addressed to the IP address associated with the mobile station 20 are first delivered to the HA 320 associated to the mobile station 20. The HA 320 then reroutes the received packet data to the connected FA/SR 310 by similarly encapsulating the received IP packet within another IP packet addressed to the FA/SR 310. The encapsulated IP packet is then transmitted over the established IP tunnel 330. The FA/SR 310 then extracts the original packet data from the received IP packet and forwards the extracted data through the serving VMSC 40 to the mobile station 20 by way of radio-interface 100 as described above.

As illustrated above, the only mobile telecommunications nodes utilized for effectuating the communication of packet data with a mobile station are the VMSC 40 and base station 30 serving that particular geographic area. Accordingly, the VMSC 40 and BS 30 are used as the very last leg of the communication link to deliver packet data via over-the-air interface 100 toward the mobile station 20. Mobility management (MM) for maintaining the current location of a mobile station 20 and for rerouting packet data to the traveling mobile station 20 are performed via separate packet data communications nodes, such as a home agent (HA) and a foreign agent (FA).

Reference is now made to FIG. 4 illustrating the handover of a mobile station 20 within an MIM network. As described above, the mobile station 20 traveling within a particular geographic area requests packet communication by transmitting a packet communication request 400 towards the serving BS1 30. The BS1 30 relays the request 410 to the connected VMSC1 40. The VMSC1 40 determines that this request is associated with packet data communication and establishes an IP communication link 420 with the foreign agent / serving router (FA/SR1) 310 serving that particular geographic area. As a result, a Point-to-Point Protocol (PPP)

In order to deliver incoming packet data towards the mobile station, the HA 320 needs a corresponding foreign agent (FA) located within the visited geographic area. However, since conventional PMM network 10 does not include a foreign agent, no IP tunnel can be established between the HA 320 and the PMM network 10. Therefore, in accordance with the teachings of the present invention, a foreign agent (FA) 310 is introduced into the PMM network 10 to effectuate an IP tunnel between the home agent (HA) 320 and the PMM network 10.

When the MIM mobile station 20 roams into a new geographic area within the PMM network 10, the mobile station 20 performs a registration in a conventional manner by transmitting a location registration request 630 over the air-interface 100. The mobile station 20 may further be associated with a data terminal equipment (DTE) 20A. The base station (BS) 30 receives the requests and forwards it to the connected VMSC 40. The VMSC 40, in turn, performs an authentication procedure by transmitting a Subscriber Authentication Information Retrieval Request 640 to an associated gateway location register (GLR, also known as a visitor location register VLR) 620. The GLR 620, in turn, transmits an Inter-networking Authentication Information Retrieval Request signal 650 to a home location register (HLR) 50 associated with the registering mobile station 20. The associated HLR 50 authenticates the subscriber and informs the GLR 620 with necessary authentication data via Inter-working Authentication Information Retrieval Response signal 660. Such data include the authentication keys associated with the mobile station 20. The GLR 620, in turn, informs the results 670 back to the requesting VMSC 40. The VMSC 40 then transmits an Authentication Request signal 680 to confirm the authentication data with the mobile station 20. In response, the mobile station 20 provides the requested authentication data via an Authentication Response signal 690. After verifying the received data and confirming the mobile station 20, a Location Registration Acknowledgment signal 700 is transmitted to the mobile station 20 by way of air-interface 100. The mobile station 20 is now registered to access the serving mobile telecommunications network for normal mobile services (i.e., voice call connection).

HA 320 associated with the roaming mobile station 20 and forwards the message 800 to the identified HA 320. The HA sends a Mobile IP Registration Reply message 810 back to the FA/GPMSC 310/70 and further establishes a second IP tunnel 755 with the serving FA 310. The FA/GPMSC 310/70 then forwards such a message 820 to the DTE 20A. A data delivery between the HA 320 and the DTE 20A is effectuate thereafter. For example, for incoming data packets 830 addressed towards the DTE 20A, the packets are initially received by the HA 320 and routed to the DTE 20A via the second IP tunnel 755 and the first IP tunnel 750. For outgoing data packets 900 originated from the DTE 20A, the packets are first routed by the first IP tunnel 750 towards the FA 310 and then, for example, to an appropriate external network 900.

The GPMSC 70 associated with the PMM network 10 further includes an interface module 600 for interfacing and communicating with the newly introduced FA 310. Furthermore, in order to facilitate the DTE's PPP establishment request, the GPMSC 70 is further equipped with a PPP server 610 in accordance with the teachings of the present invention.

Accordingly, by introducing the foreign agent (FA) 310 within the PMM compatible network 10, the home agent (HA) 320 located with the home MIM network 300 is able to establish an IP tunnel with the new FA 310 and effectuate packet data communication with the mobile station 20 roaming within an otherwise incompatible network.

FIGURE 7 is a block diagram of the PMM data packet network 10 illustrating the hand over of a mobile station 20 associated with the MIM network from a visited mobile switching center 1 (VMSC1) 40A to a VMSC2 40B in accordance with the teachings of the present invention. As described in detail in FIGS. 5 and 6, the mobile station 20 associated with the MIM network roams into the PMM network 10 and is being served by the VMSC1 40A. An IP tunnel 750A is established between a visited packet mobile switching center 1 (VPMSC) 80A associated with the serving VMSC1 40A and the gateway packet mobile switching center (GPMSC) 70 as described above. The GPMSC 70 then interfaces with a foreign agent (FA) 310 for communicating packet data with an associated home

Furthermore, the signaling sequences utilized by the roaming mobile station are incompatible with the MIM network. The MIM network 300 expects the mobile station to perform a Mobile IP Registration before transmitting user data thereto. However, a standard PMM associated mobile station does not perform such a registration. Therefore, in order to resolve such an incompatibility, in accordance with the teachings of the present invention, a new home agent (HA) 320A is introduced into the PMM network 10 for purposes of serving a PMM network associated mobile station currently roaming within the MIM network 300.

The registration of the mobile station 20 associated with the PMM network and roaming within the MIM network 300 is performed in a conventional manner as fully described above. For example, the mobile station 20 roams into a new geographic area within the MIM network 300 and performs a registration by transmitting a location registration request 630 over the air-interface 100. The base station (BS) 30 receives the request and forwards it to the connected VMSC 40. The VMSC 40, in turn, performs an authentication procedure by transmitting a Subscriber Authentication Information Retrieval Request signal 640 to an associated gateway location register (GLR, also known as a visitor location register VLR) 620. The GLR 620, in turn, transmits an Inter-networking Authentication Information Retrieval Request signal 650 to a home location register (HLR) 50 associated with the registering mobile station 20. The associated HLR 50 authenticates the subscriber and informs the GLR 620 with necessary authentication data via an Inter-working Authentication Information Retrieval Response signal 660. Such data include the authentication keys associated with the mobile station 20. Additional subscription data, such as special subscriber feature data, may further be down-loaded to the GLR 620.

The GLR 620, in turn, informs the results 670 back to the requesting VMSC 40. The VMSC 40 then transmits an Authentication Request signal 680 to confirm the authentication data with the mobile station 20. In response, the mobile station 20 provides the requested authentication data via an Authentication Response signal 690. After verifying the received data and confirming the mobile station 20, a Location Registration Acknowledgment signal 700 is transmitted to the mobile

MIM network 300. Since the IP address associated with the mobile station 20 also represent the home PMM network 10, all incoming packet data addressed toward the mobile station 20 are first received by the gateway packet mobile switching center (GPMSC) 70 located within the home PMM network 10. After communicating with the associated HLR 50, instead of establishing an IP tunnel with a visited packet mobile switching center (VPMSC, refer to FIG. 1), the GPMSC 70 realizes that the mobile station 20 is currently traveling within the MIM network 300 and instead establishes an IP tunnel 1030 with the newly introduced HA 320A. The HA 320A then delivers the received packet data towards the MICE 1000 over the established IP tunnel 1015. The MICE 1000 then extracts the encapsulated packet data and delivers the extracted data to the VMSC 40 currently serving the mobile station 20.

The MICE 1000 is further associated with a serving router 1100. For outgoing packet data originated by the roaming mobile station 20, there is no need for the packet data to be delivered to the home network 10. Instead, the serving router 1100 associated with the MICE 1000 connects to other external networks, if necessary, and transmits the received data packets 900 directly.

FIGURE 10 is a block diagram illustrating the hand over of a mobile station associated with a PMM network being handed over from a VMSC1 40A to a VMSC2 40B within a visited MIM network 300 in accordance with the teachings of the present invention. In a manner as described in FIGS. 8 and 9, the mobile station 20 registers with and is being served by the VMSC1 40A. When the mobile station 20 travels out of the VMSC1 coverage area and travels into a new geographic area being served by the new VMSC2 40B, the mobile station 20 again performs a packet communication registration therewith. The transmitted registration signal is received by a new BS2 30B providing radio coverage for that particular geographic area and forwarded to the associated VMSC2 40B. In a conventional manner as described above, the VMSC2 40B then communicates with the GLR 620 to authenticate the mobile station (signal 1140). The GLR 620, realizing that the mobile station 20 is a PMM associated mobile station, accordingly informs the VMSC2 40B. The VMSC2 40B then issues a tunnel establishment request to the MICE 1000. The

WHAT IS CLAIMED IS:

1. A mechanism for enabling a mobile station associated with a first packet data network to roam within a second packet data network, said mobile station assigned with a network independent Internet Protocol (IP) address wherein said first packet data network comprises a home agent for processing incoming packets towards said mobile station and wherein said first packet data network and said second packet data network use incompatible packet routing mechanisms, comprising:

a foreign agent within said second packet data network for communicating packet data with said mobile station;

a first IP tunnel connecting said foreign agent within said second packet data network with said home agent within said first packet data network;

a gateway node within said second packet data network for connecting to said foreign agent;

a visited packet serving node within said second packet data network, said visited packet serving node communicating with said gateway node; and

a visited mobile switching center associated with said visited packet serving node for providing radio coverage toward said mobile station.

2. The network of claim 1 wherein said gateway node comprises a gateway packet mobile switching center (GPMSC).

3. The network of claim 2 wherein said GPMSC further comprises an interface module for connecting said GPMSC with said FA.

4. The network of claim 2 wherein said GPMSC further comprises a Point-to-Point Protocol (PPP) server for establishing PPP connection with said mobile station.

5. The network of claim 1 wherein said visited packet serving node comprises a visited packet mobile switching center (VPMSC).

network to connect to said second foreign agent routing data for said mobile station associated with said first packet data network.

12. The system of claim 11 wherein said GPMSC further comprises a Point-to-Point Protocol (PPP) server enabling said GPMSC to establish a PPP connection with said mobile station.

13. The system of claim 10 wherein said first communications link comprises an IP tunnel wherein one IP packet is encapsulated within another IP packet and transported over said IP tunnel.

14. A system for enabling a mobile station associated with a first packet data network to roam within a second packet data network, said mobile station assigned with an Internet Protocol (IP) address associated with said first packet data network wherein said first packet data network comprises a gateway packet mobile switching center (GPMSC) for processing incoming packets toward said mobile station and wherein said first packet data network and said second packet data network use incompatible packet routing mechanisms, comprising:

a home agent associated with said first data packet network;

a communications link connecting said home agent with said GPMSC;

a foreign agent associated with said second data packet network;

a IP tunnel connecting said home agent within said first packet data network with said foreign agent within said second packet data network for communicating packet data therebetween; and

a mobile switching center associated within said second packet data network and interfaced with said foreign agent for delivering packet data toward said mobile station over air-interface.

15. The system of claim 14 wherein said foreign agent further comprises a serving router for routing packet data communicated with said mobile station.

21. The system of claim 18 wherein said foreign agent further comprises a serving router for establishing a Point-to-Point Protocol (PPP) connection with said second home agent.

22. The system of claim 21 wherein said foreign agent communicates with said MSC over a first packet data link and in case said mobile station travels into a new geographic area being covered by a new MSC within said second packet data network, said foreign agent further comprises means for releasing said first packet data link and establishing a new packet data link with said new MSC.

23. A system for enabling a first mobile station and a second mobile station to communicate packet data within a mobile telecommunications network, comprising:

a first packet data network further comprising:

a gateway packet mobile switching center (GPMSC) for routing packet data toward said first mobile station;

a home location register (HLR) for keeping track of the current location of said first mobile station, said HLR interfaced with said GPMSC; and

a visited packet mobile switching center (VPMSC) currently serving said first mobile station, said VPMSC connected to said GPMSC and communicating said packet data with said first mobile station;

a second packet data network further comprising:

a first home agent for routing packet data toward said second mobile station;

a first foreign agent for connecting with said home agent for communicating packet data with said second mobile station traveling within a particular geographic area;

a serving router connected to said foreign agent for delivering said packet data to said second mobile station;

a second foreign agent within said first packet data network, said second foreign agent communicating with said first home agent associated with said second

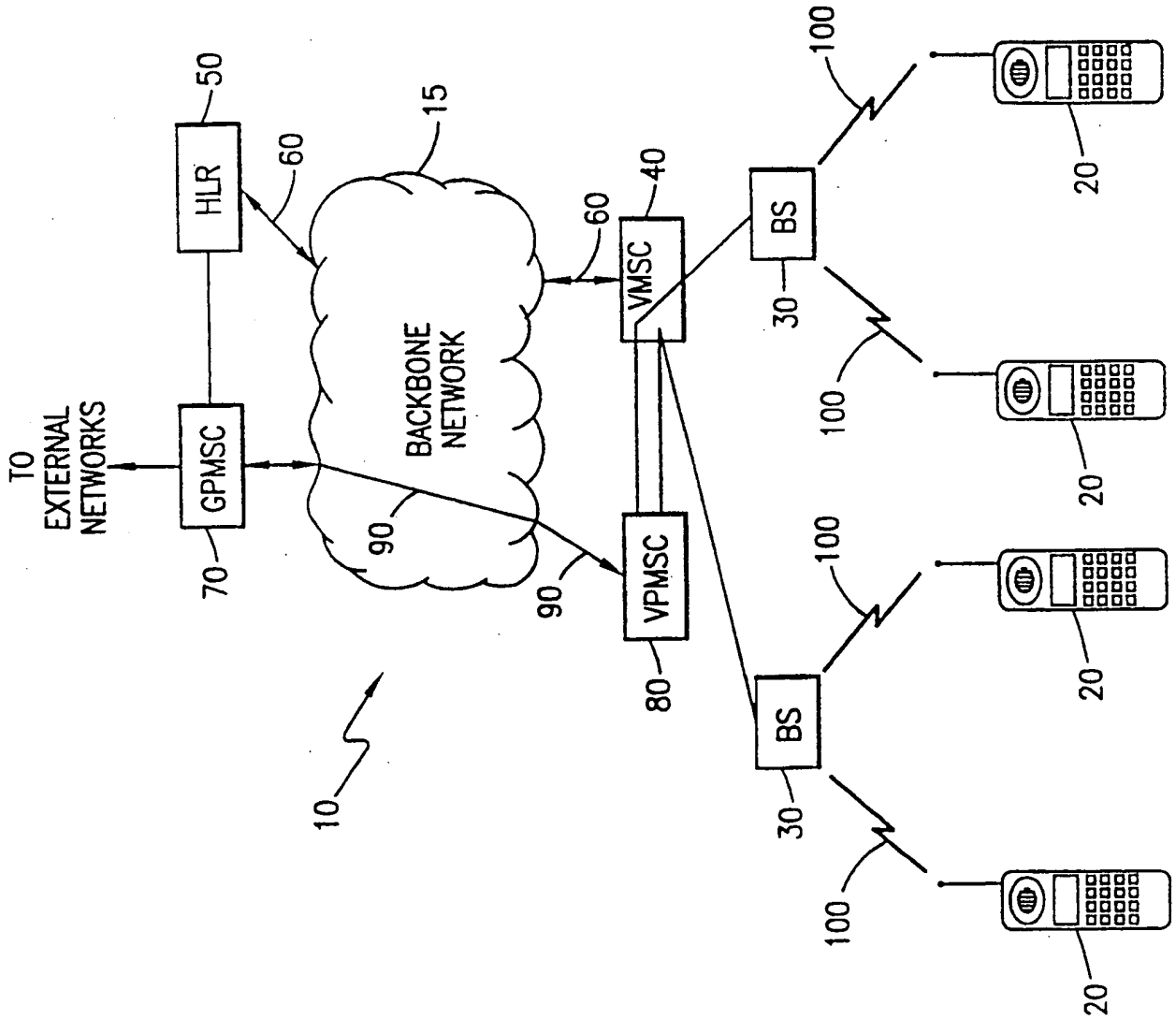
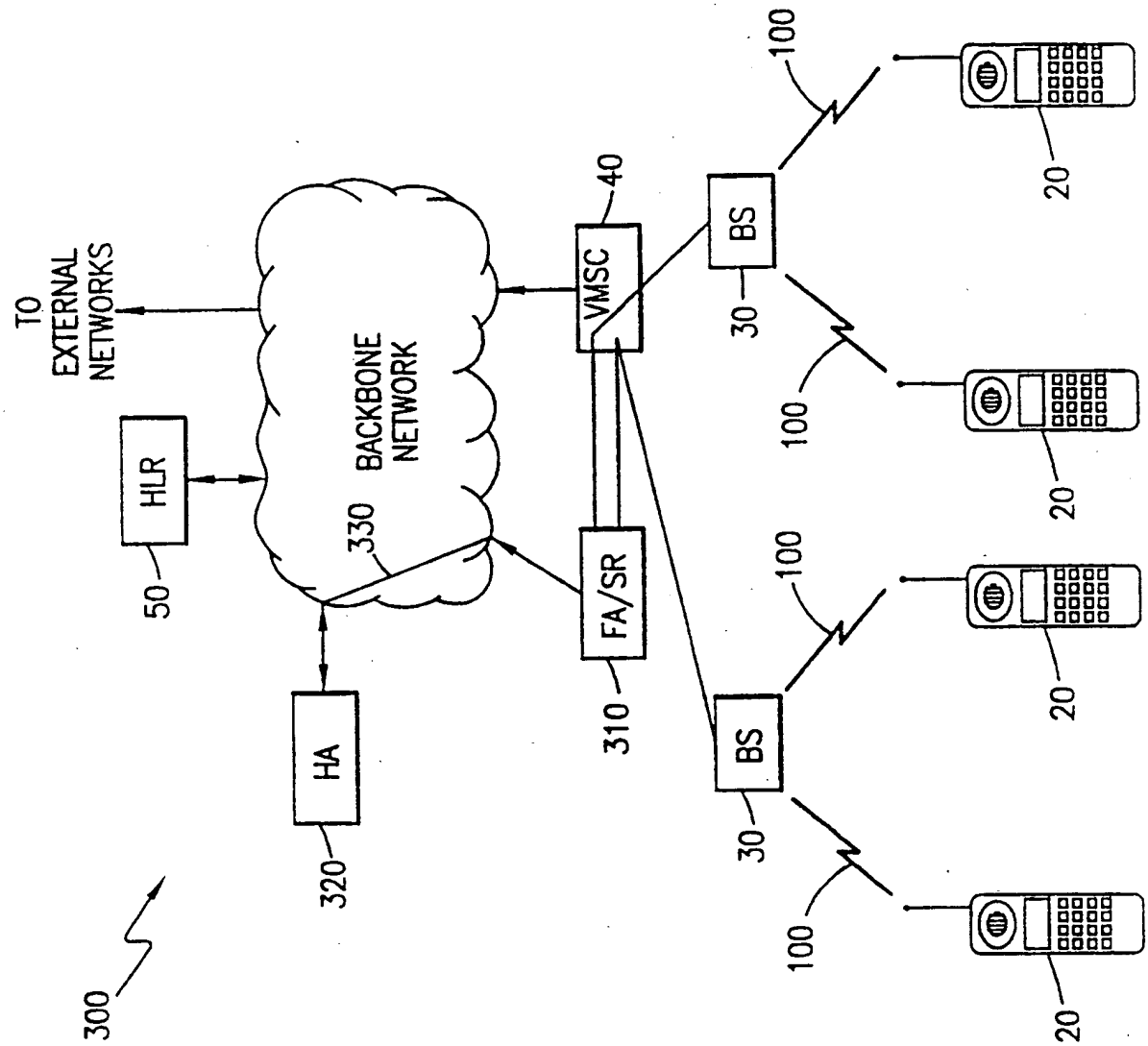

TO EXTERNAL NETWORKS
GPMSC
HLR
BACKBONE NETWORK
VMSC
VPMSC
BS
BS
10
15
20
30
40
50
60
70
80
90
100

FIG. 1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HLR
50
BACKBONE NETWORK
330
HA
320
300
VMSC
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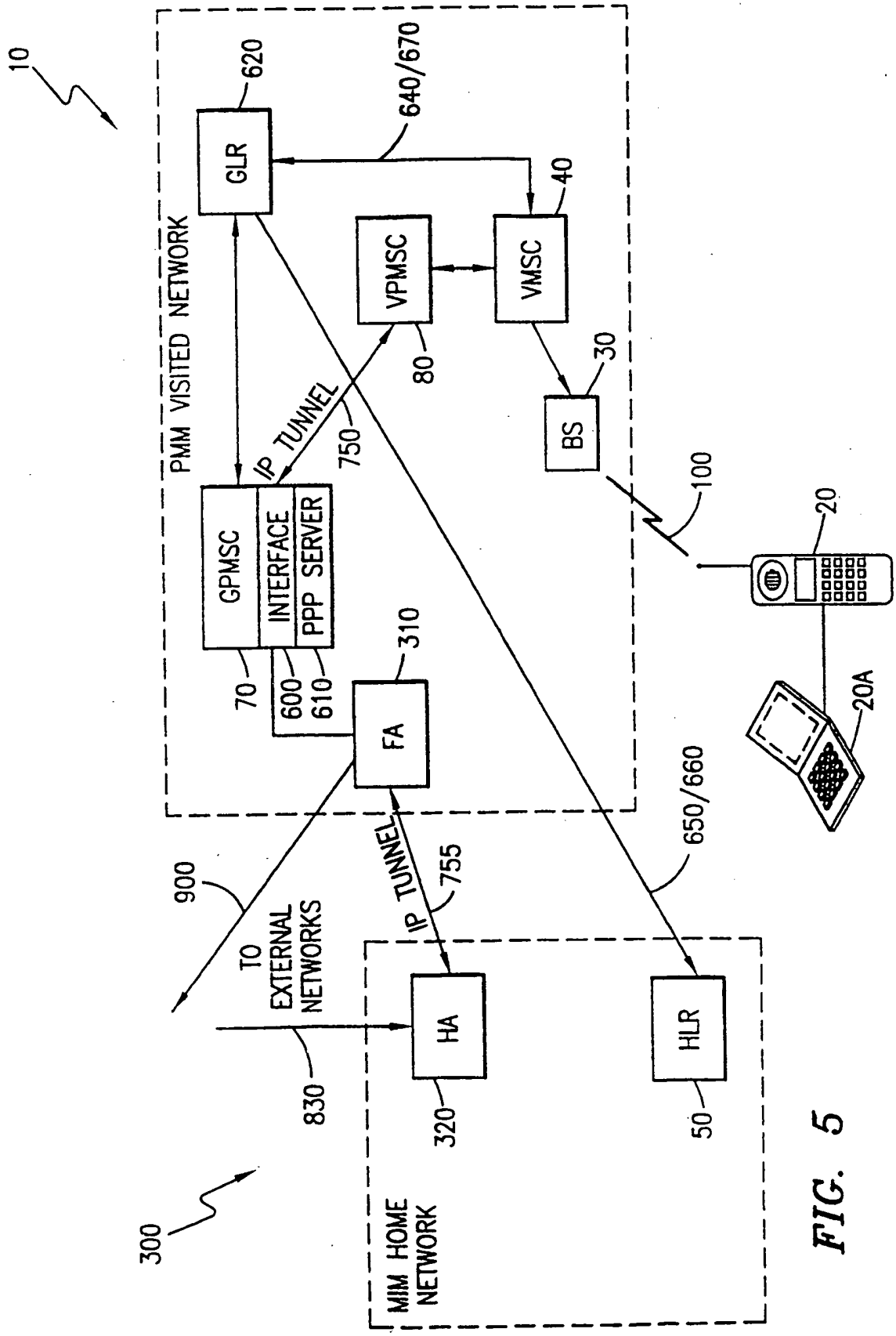
FIG. 3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GLR
620
640/670
40
VPMSC
VMSC
80
30
BS
100
20
20A
IP TUNNEL
750
GPMSC
INTERFACE
PPP SERVER
70
600
610
FA
310
650/660
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IP TUNNEL
755
830
HA
320
HLR
50
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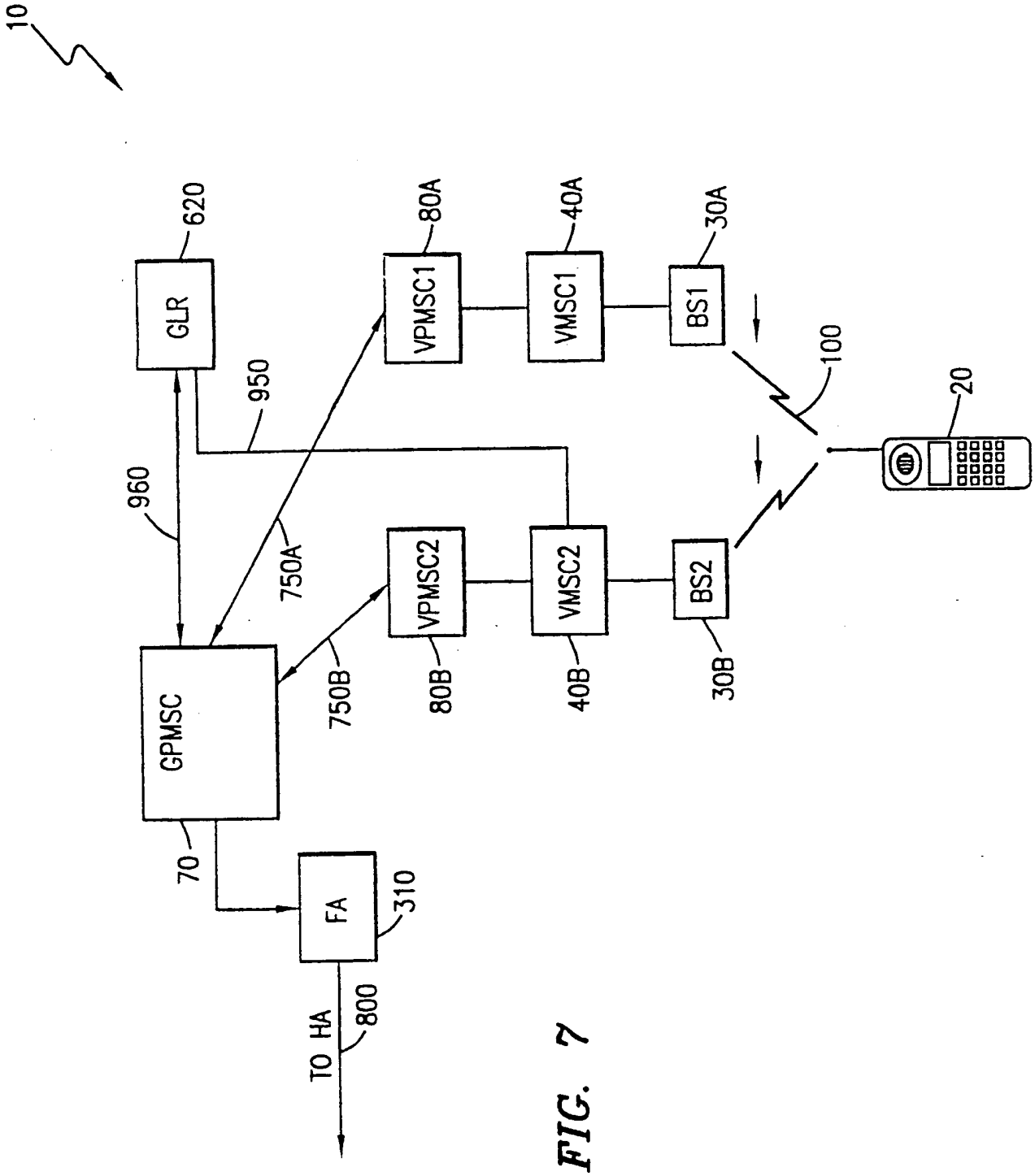
MIM HOME NETWORK

FIG. 5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GLR
80A
VPMSC1
40A
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30A
BS1
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20
950
960
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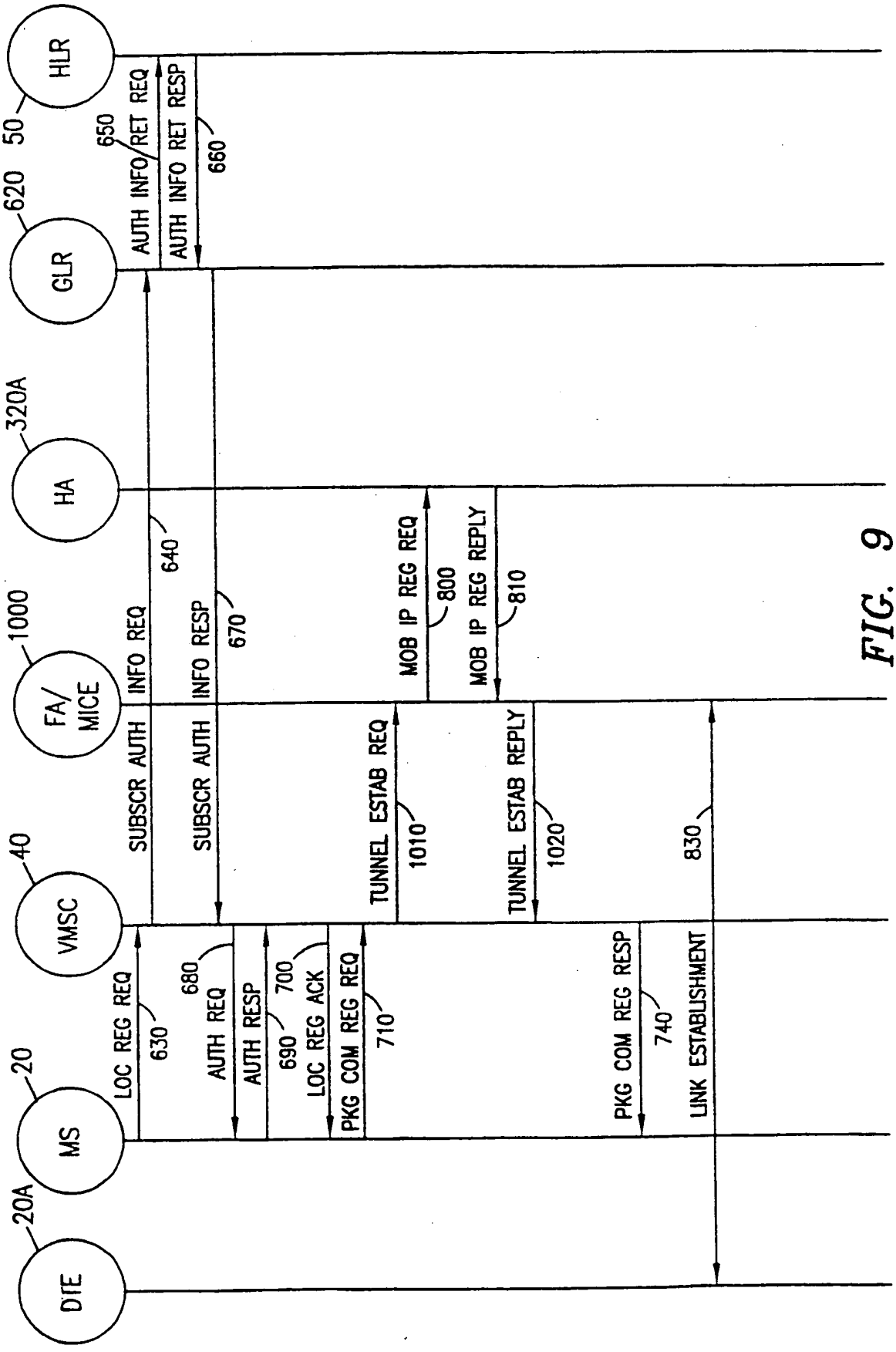
TO HA
800

FIG. 7


DTE
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MS
20
VMSC
40
FA/
MICE
1000
HA
320A
GLR
620
HLR
50
LOC REG REQ
630
AUTH REQ
680
AUTH RESP
690
LOC REG ACK
700
PKG COM REG REQ
710
SUBSCR AUTH
SUBSCR AUTH
INFO REQ
640
INFO RESP
670
AUTH INFO RET REQ
650
AUTH INFO RET RESP
660
TUNNEL ESTAB REQ
1010
TUNNEL ESTAB REPLY
1020
MOB IP REG REQ
800
MOB IP REG REPLY
810
830
PKG COM REG RESP
740
LINK ESTABLISHMENT

FIG. 9